INNOVATIVE IN-HOUSE MODELS TO EVALUATE THE EFFECT OF ENVIRONMENTAL STRESSORS (PHYSICAL & CHEMICAL) ON HAIR FIBERS

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INTRODUCTION

Quality of hair is very important for self-confidence as well as a very important part of appearance and self-esteem. Hair reflects the personality and hair damage is considered as aesthetic imperfections. Hair cuticle is the hair's first line of defense against environmental stressors. It's alteration causes penetration of stressors, such as pollution or chemical molecules into the fibers and promotes damaged, brittle and weak hair. An Intact cuticle is therefore crucial for healthy hair. Our current lifestyles involve constant exposure to stressors (chemicals and physical stresses…) that weaken our hair fibers; This results in damaged hair that looks dull and seems asphyxiated. Unlike in skin investigation, the effect of environmental stressors on hair fibers has not often been studied and published in scientific papers. Precise evaluation methods to track modulations of the stressors on hair fibers are thus necessary. This explains the interest in developing several and complementary models to provide experimental conditions that mimic the harmful effects of environmental stressors on hair fibers. The aim of this study is to identify the damage of stressors on hair fibers and then measure the performance of appropriate hair care products.

METHODS

HAIR SAMPLES

- Tresses of virgin Caucasian hair were used.

SEM OBSERVATIONS

- FEG ZEISS GeminiSEM 300
- Coating: 2nm of gold
- Working distance: 6.2-6.5mm
- Electron High Tension: 2-8 kV

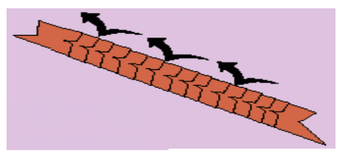
« CHEMICAL » HAIR STRESSORS

- Air-pollution:

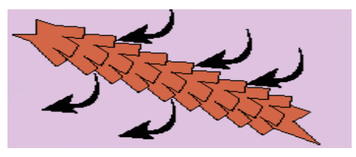
Carbon micro-particles (5-50 µm) were used to simulate air pollution and were made fluorescent with a specific probe. Prepared fluorescent carbon particles were then mixed with hair under a stable flux of compressed air. Microscopic observation was then realized and particles on hair were quantified by specific software. The quantity of micro particles on hair is inversely proportional to the degree of protection by the hair care product against pollution: Damaged cuticles act as "storage area" and increase the accumulation of pollution on hair fibers.

- Chemical-stress:

Hair tresses were placed in a bath of Chlorine (swimming-pool water modelling). In order to measure the integrity of the hair cuticles, the penetrating capacity of a fluorescent probe into the hair was studied. Hair were then sectioned and analyzed. The fluorescent intensity in the hair cortex is directly proportional to the degree of hair damage.



Healthy hair: low porosity => the fluorescent probe does not penetrate

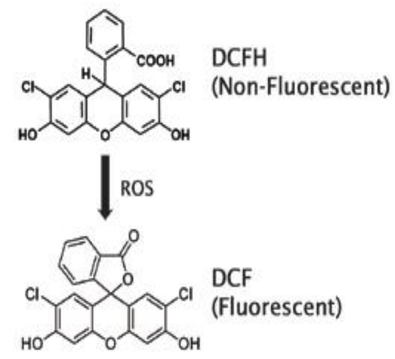


Damaged hair: high porosity => The fluorescent probe enters into the cortex

« PHYSICAL » HAIR STRESSORS

- UV-irradiation:

Hair pieces were cut from tresses and spread in a homogeneous manner in Petri dishes. UV(A+B) irradiations were realized using a Biosun irradiator. 2',7'-dichlorodihydrofluorescein (DCFH), a fluorogenic Reactive Oxygen Species (ROS) sensitive probe, was used to measure the amount of ROS generated on hair after UV irradiations.



- Heat damage:

The fibers received the application of heat directly from a straightening iron at 235°C over the entire length of the hair shaft. Several cycles of the heating process were done (one cycle is equivalent to 5 seconds of heating at 235°C followed by 15 seconds of cooling at room temperature). In this work, a flat iron model Babyliss i-pro 235 ionic XL Wet&Dry was used.

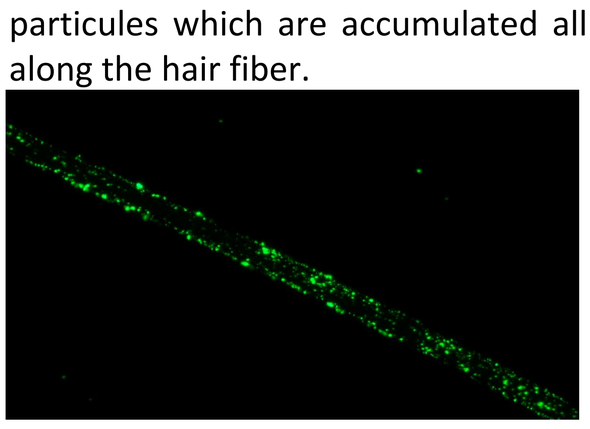
Damage on hair cuticles was observed by SEM observations.

RESULTS

« CHEMICAL » HAIR STRESSORS

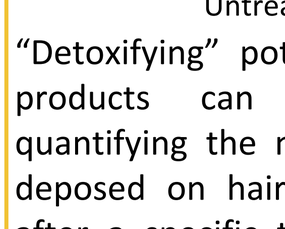
AIR-POLLUTION

The image below shows hair exposed to fluorescent carbon micro-particules which are accumulated all along the hair fiber.

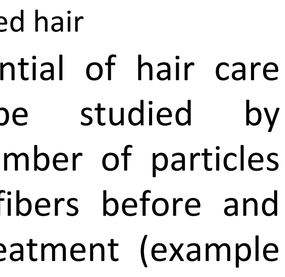


Untreated hair

"Detoxifying" potential of hair care products can be studied by quantifying the number of particles deposed on hair fibers before and after a specific treatment (example below):



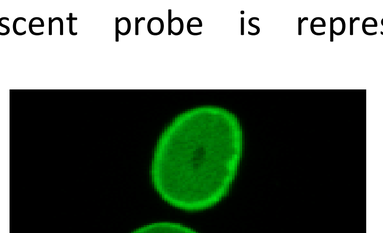
Untreated hair
(Many fluorescent particles)



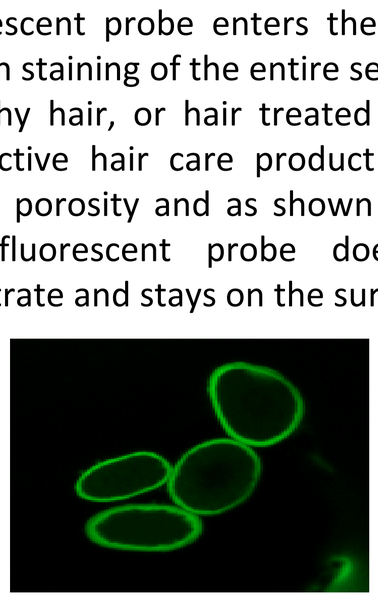
Treated hair
(Few fluorescent particles)

CHLORINE

An image of sectioned hair fibers after chlorine chemical stress (swimming pool water modelling) followed by dipping the hair in a fluorescent probe is represented below



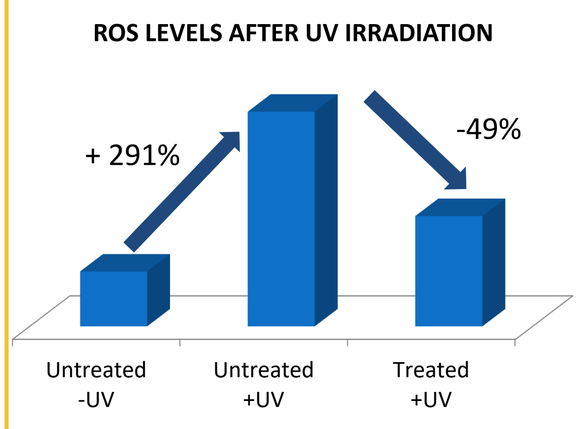
The porosity of the chlorine damaged hair is high and as shown above the fluorescent probe enters the cortex (green staining of the entire section)
Healthy hair, or hair treated with a protective hair care product shows lower porosity and as shown below, the fluorescent probe does not penetrate and stays on the surface.



« PHYSICAL » HAIR STRESSORS

UV (A+B) IRRADIATION

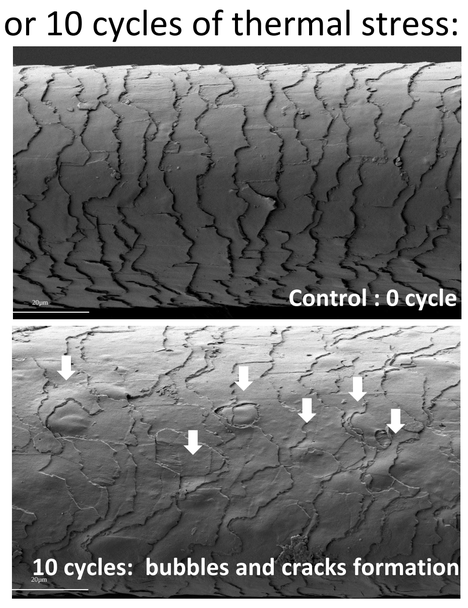
The graph below provides the mean fluorescence obtained (fluorescence is directly proportional to the quantity of ROS).



UV irradiation increased the accumulation of ROS on hair fibers. ROS production on hair is the first step involved in degradation (oxidation) of essential hair proteins and lipids.
Long term consequences: weakening of the hair fibers. Hair treated with appropriate protective hair care product can decrease the UV induced ROS on hair as shown above.

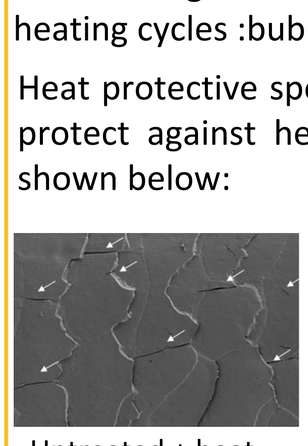
HEAT

SEM images of hair fibers subjected to 0 or 10 cycles of thermal stress:



Heat damage was observed after 10 heating cycles :bubbles and cracks.

Heat protective specific hair care can protect against heat degradation as shown below:



Untreated + heat

Treated + heat

CONCLUSION

- In-house developed method for the evaluation of pollution on hair is suitable to evaluate the "detoxifying" potential of hair care products.
- Chemical stress, as chlorine, making hair porous, can be evaluated by the rate of penetration of the fluorescent probe into hair cortex.
- UV (A+B) irradiations increase ROS on hair fibers, and the developed method can help to evaluate protective products against UV damage.
- Heat damage can be observed on the surface of hair fibers by SEM. Visible morphological alteration can be observed after 10 heating cycles.
- The above described methods appear to be suitable for the evaluation of the effects of environmental (physical & chemical) stressors on hair fibers permitting the development of appropriate hair care products.

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